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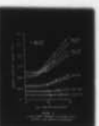
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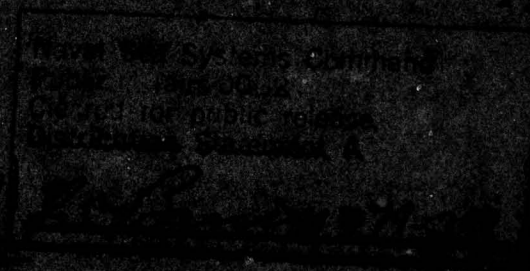
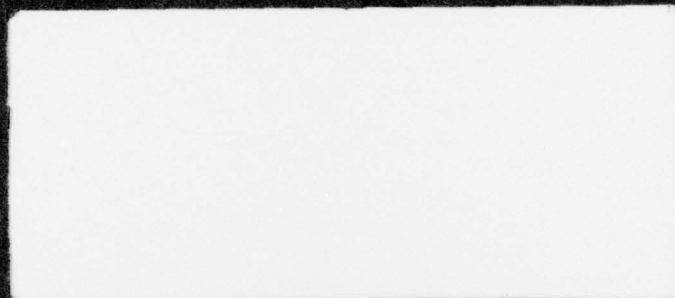


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THE EFFECT OF TRANSVERSE SIDE LOAD ON  
SMALL WATERPLANE AREA TWIN HULL  
(SWATH) STRUCTURES

REPORT 6114-041-79

JANUARY 1979

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By Colen G. Kennell

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This study examines the influence of transverse side load and ship configuration on the structural weight of SWATH ships. The results show that small ships are less sensitive than large ships to side loads, and that long slender ships will have heavier structure than short full ships. ↗



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Section 1  
INTRODUCTION

The importance of dynamic transverse side forces in the design of Small Waterplane Area Twin Hull (SWATH) ships has been recognized for several years. Algorithms for predicting these loads have been developed at DTNSRDC by combining theoretical analysis with limited model test data. However, the effect of these predicted side loads on the structure of representative SWATH configurations has not been investigated. This study is intended to partially fill that void.

Section 2 of this report details the approach adopted to investigate the problem including details of the hull forms studied. Section 3 contains the results of the study. Conclusions derived from the study are discussed in Section 4.

This work was completed as part of the NAVSEC SWATH effort funded by NAVSEA Work Request WR9G105. NAVSEC JON 329MP01 was assigned to the task.



## Section 2

### APPROACH

The approach adopted for this study was to calculate the primary structural weight of representative SWATH configurations as a function of side force. Primary structure includes shell plating, stiffeners, bulkheads, decks, platforms, and inner bottom. The maximum side force considered was twice the displacement of each configuration. The structural weight calculations were made with a computer program developed for the purpose by combining subroutines WTPRI, SSS11, SSS18, and AREO from NAVSEC's SWATH Synthesis Model.

Several important assumptions are made in the program. First, center wells in the box or cross-structure have been excluded from all configurations. While wells may be desirable for some potential missions, a general design approach for wells in SWATH structures has not been developed.

The second assumption is that only the box structure directly above the struts is effective in resisting transverse bending loads. Improvement on this assumption will require detailed examination of stress flow in box and struts of representative SWATH structures.

Third, all strut shell structure has been assumed to be effective in bending. In particular, end effects associated with box/strut transition have been ignored. More detailed analysis of these problems will be required to make an improved assumption.

SWATH configurations selected for this study were chosen to be representative of current design practice. Three parent hulls were selected from a recent parametric study (reference (1)).

Characteristics of the parent forms are given in Table 1. Sketches of the three configurations are shown in Figure 1. It should be noted that present computer programs cannot model the complex hull shape of the multistrut shown in Figure 1. Instead, an approximation to the hull shape was used. This equivalent form consisted of a 180 foot parabolic tail section and a 180 foot elliptical nose section. The maximum hull diameter and draft were selected to provide hull and strut volumes in the equivalent hull equal to those in the parent form. Characteristics of the equivalent multistrut are shown in Table 1. A sketch of the equivalent is also shown in Figure 1.

The proportions of these parent forms were Froude scaled to displacements of 2000, 5000, 10,000, and 20,000 tons. Box height and box clearance were held constant at 14 feet and 20 feet respectively.

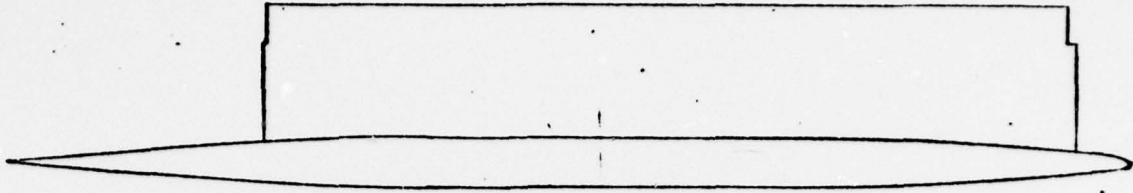
All of the configurations generated in this manner have one interior deck in the box and an inner bottom. Twin deck variants of the 20,000 ton configurations were also examined.

TABLE 1

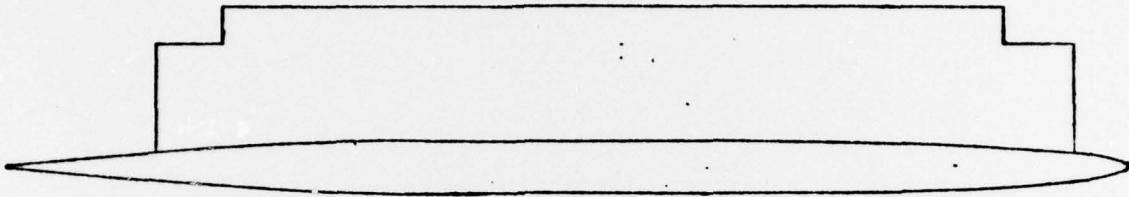
## Parent Form Characteristics

	Thin Single Strut	Thick Single Strut	Multi Strut	Equivalent Multi-Strut
Hull Length (ft)	400	400	360	360
Maximum Diameter (ft)	19.3	18.4	25	22.6
Prismatic Coefficient	0.7	0.7	0.5	0.6
Draft (ft)	33.8	32.2	37.8	36.7
Diameter Ratio	1.0	1.0	2.1	1.0
Strut Length (ft)	326	287	110	110
Thickness (ft)	8	11	7	7
Waterplane Coefficient	0.75	0.75	0.88	0.88
Strut Gap (ft)	-	-	86	86
Displacement (tons)	6306	6125	6051	6051
Box Clearance (ft)	20	20	20	20
Box Length (ft)	275	284	233	233
Box Width (ft)	99.2	90.4	117	117
Box Height (ft)	14	14	14	14
GMT (ft)	10	10	10	10
GML (ft)	86	84	-	-
Waterplane Area (Sq. ft)	3913	4736	-	-

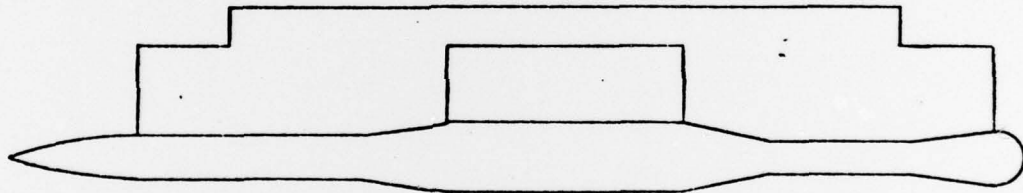
THICK SINGLE STRUT



THIN SINGLE STRUT



MULTI STRUT



EQUIVALENT MULTI STRUT

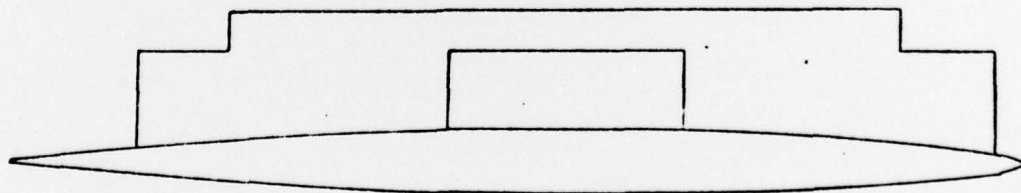


FIGURE 1  
PARENT FORM SKETCHES

The two single strut parent forms were selected to demonstrate the effects of strut thickness and waterplane area. Both forms have roughly the same longitudinal GM and transverse GM in keeping with DTNSRDC recommendations (reference (1)). However, the thick strut form requires 20 percent more waterplane area than the thin strut form to achieve these metacentric heights and the thin strut is forty feet longer than the thick strut. The thick strut form is more in line with DTNSRDC seakeeping guidelines on waterplane area than the thin strut. This variation in strut form is particularly interesting since the side load algorithms presently available are particularly sensitive to strut length.

The multistrut forms have a total strut length of 306 feet and a box length of 233 feet. The two assumptions discussed previously result in 147 feet of the box structure (63 percent of box length) being effective in carrying bending loads. Use of a centerwell in such a concept would result in more box structure being effective in bending. However, added weight would be required to beef up structural members around the well to keep stresses within material limits.



### Section 3

#### RESULTS

The parent hull configurations and their geosyms were used as input to the computer program. Data calculated include predicted side load as well as weights and densities for box, strut, and hull primary structure of each configuration. Figure 2 shows the total primary structure of the single strut forms plotted against side load/displacement. The upper boundary on each band is the thin strut curve and the lower boundary is the thick strut curve. Figure 3 is a similar plot for the multistrut forms. The circles on both plots represent the predicted side loads for the different configurations.

For single strut forms, predicted side load was calculated as:

$$\text{side load/displacement} = (-0.5 + LBT) \times D$$

Where

$$L = 0.511 + 0.0038x (\text{strut length})^2 / (\text{Displacement})^{2/3}$$

$$B = 0.9582 + 0.0025 \times (\text{strut CL separation})^2 / (\text{Displacement})^{2/3}$$

$$T = 0.3245 + 0.1905 \times (\text{draft})^2 / (\text{Displacement})^{2/3}$$

$$D = 1.43 - 0.0995 \times \ln (\text{Displacement}/1000)$$

The corresponding multistrut equation is:

$$\text{side load/displacement} = LBT D$$

Where

$$L = 0.5449 + 0.0215 \times (\text{FWD STRUT LENGTH} + \text{AFT STRUT LENGTH})^2 / 4 \times (\text{Displacement})^{2/3}$$

$$B = 0.951 + 0.0006 \times (\text{strut CL separation})^2 / (\text{Displacement})^{2/3}$$

$$T = 0.7731 + 0.0696 \times (\text{Draft})^2 / (\text{Displacement})^{2/3}$$

$$D = 0.3707 - 0.0282 \times \ln (\text{Displacement}/1000)$$

Clearly in all cases, side loads have negligible effect on the structures of small ships for the range of side load investigated. At 2,000 tons the curves are flat. At 5,000 tons, structural weight increases for side loads greater than about one times displacement. For larger displacements, structural weight increases are required for smaller side loads. This trend is due to the assumption that the same minimum scantlings are used for all sizes.



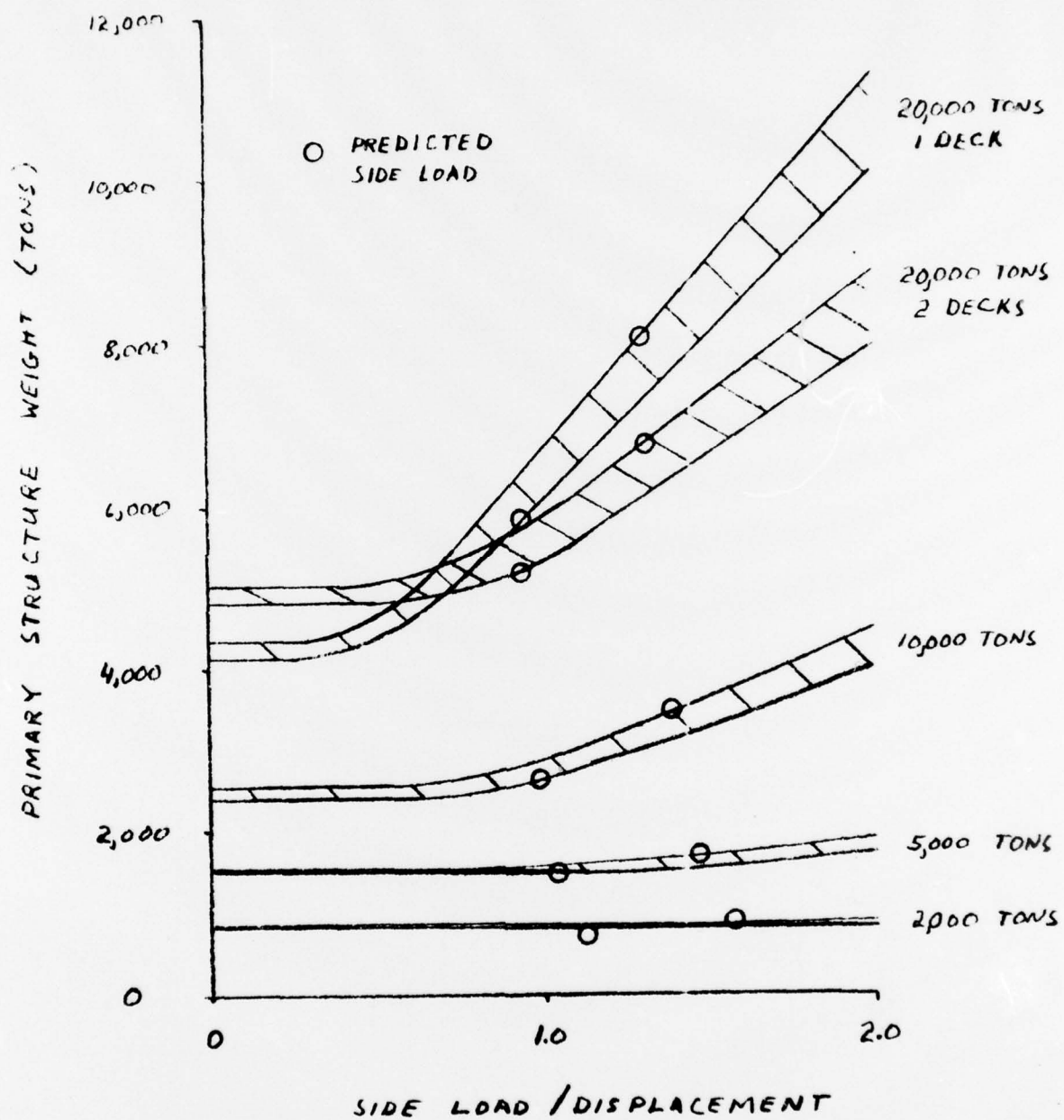


FIGURE 2  
SINGLE STRUT PRIMARY STRUCTURE WEIGHT  
VERSUS SIDE FORCE / DISPLACEMENT

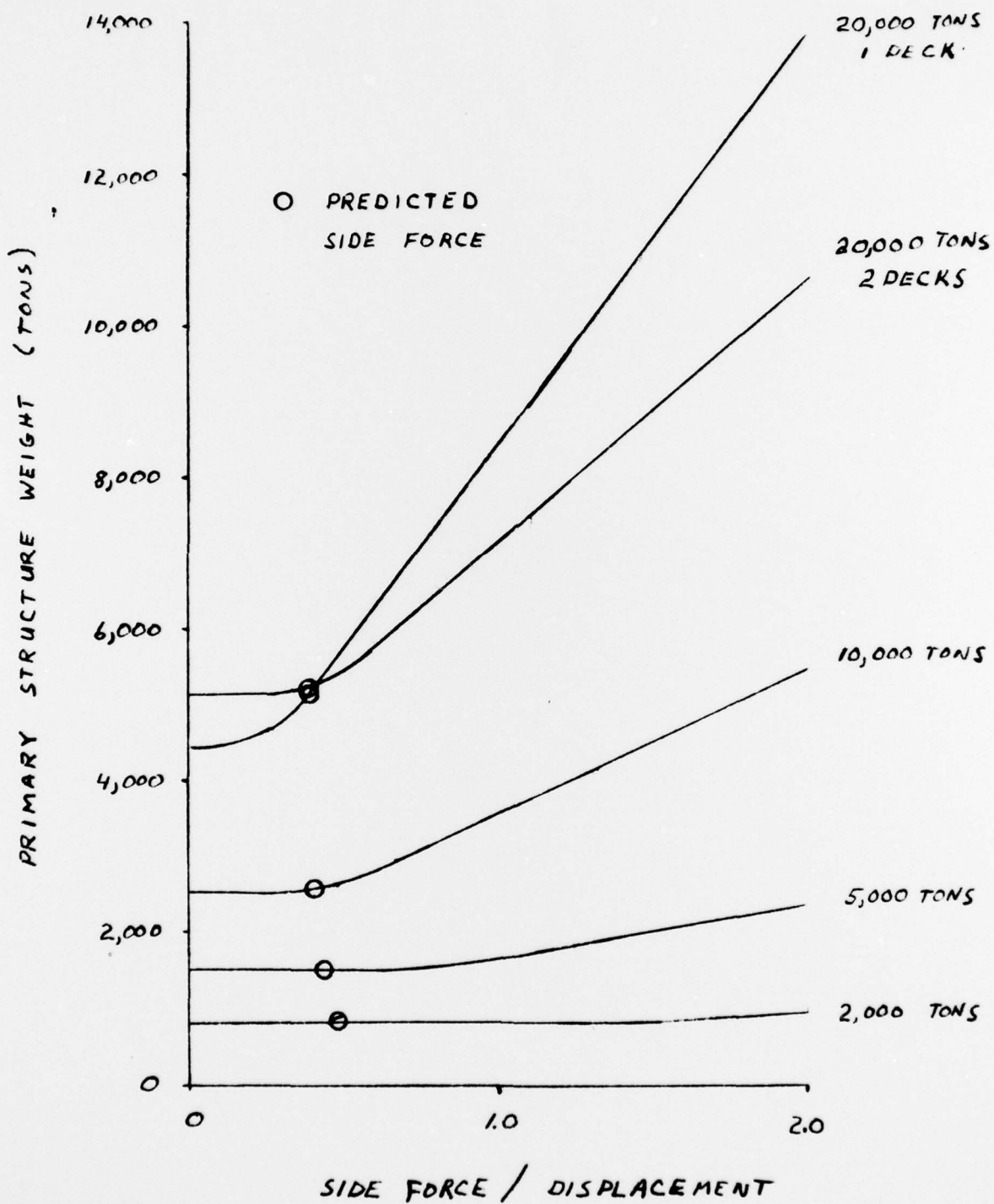


FIGURE 3  
MULTI STRUT PRIMARY STRUCTURE WEIGHT  
VERSUS SIDE LOAD / DISPLACEMENT

The single strut curves (Figure 2) show that the thick strut form is generally lighter than the thin strut form. This is particularly true for the larger sizes where the effects of the thin struts higher predicted side load are amplified by the lower structural efficiency of the thin struts.

Figure 2 also shows that the structure of large ships with two decks will probably be lighter than similar single deck ships. This trend is due to the greater structural efficiency of the deeper two deck boxes. The cross-over for 20,000 ton forms occurs for a side load of about 0.75 times displacement. Predicted side loads for both single strut forms are greater than this amount.

Comparison of the curves in Figure 2 and Figure 3 shows that the structural weights of the single strut and multi strut forms studied are generally similar. The multi strut curves show a side load dependence at somewhat lower values than the single strut curves. However, the predicted side loads are somewhat lower for the multi strut forms. As a result, the multi strut structural weights are roughly comparable to those of the thick single strut forms and somewhat lighter than the thin single strut weights. For the 2000 ton forms, no significant structural weight differences can be observed.

The data used to develop Figures 2 and 3 and the hull, strut, and box structural weight and density have been tabulated in Appendix A.

#### Section 4

#### CONCLUSIONS AND RECOMMENDATIONS

The data generated cannot be used to determine structural weight for a real design. However, conclusions regarding trends and generalities which can be reached are:

a. Independent trade-offs of seakeeping performance, resistance, or structural weight will be inconclusive.

b. Dynamic side loads are more important for large ships than for small ships.

c. Ships with long thin struts will have heavier structure than similar ships with short thick struts.

Also, several recommendations can be made based on the experience gained during this study.

a. Validity of existing side load algorithms should be ascertained for long slender forms.

b. Structural studies should eventually address:

(1) the amount of effective box material in bending for realistic box/strut combinations,

(2) the amount of effective strut material in bending for realistic strut shapes and sizes.

c. Design methods for wells should eventually be developed.

d. Structural design methodology for complex hull shapes eventually should be developed.

#### References

1. Kennell, C. and Anderson, T., "Small Waterplane Area Twin Hull (SWATH) Combatant Ship Parametric Study," NAVSEC Report 6114-048-78 dated September 1978



**APPENDIX A**  
**STRUCTURAL WEIGHT DATA**

XL,DIALH,CP,TD,AG,ALUMS	276.000	12.670	.700	1.750	20.000	1.000		
XLS,XTNVS,CWP,STGAP	190.000	7.500	.750					
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	195.000	62.300	4.000	10.000	0.000	0.000		
BOX,STRUT,MULL,TOTAL VOLUME=	170079.	66410.	40717.	205214.				
DISP=	2003.	PREDICTED SIDE LOAD=	1.124					
SIDE LOAD	0.060	.250	.500	.750	1.000	1.250	1.500	1.750
BOX DENSITY	5.213	5.213	5.213	5.213	5.213	5.213	5.213	5.213
STRUT DENSITY	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
MULL DENSITY	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
TOTAL DENSITY	6.471	6.471	6.471	6.471	6.471	6.471	6.471	6.471
BOX WEIGHT	395.704	395.704	395.704	395.704	395.704	395.704	395.704	395.704
STRUT WEIGHT	252.922	252.922	252.922	252.922	252.922	252.922	252.922	252.922
MULL WEIGHT	175.177	175.177	175.177	175.177	175.177	175.177	175.177	175.177
TOTAL WEIGHT	823.602	823.602	823.602	823.602	823.602	823.602	823.602	823.602

XL,DIALH,CP,TD,AG,ALUMS	374.000	17.200	.700	1.750	20.000	1.000		
XLS,XTNVS,CWP,STGAP	260.000	10.300	.750					
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	265.000	84.500	4.000	10.000	0.000	0.000		
BOX,STRUT,MULL,TOTAL VOLUME=	313495.	136226.	121660.	571380.				
DISP=	5002.	PREDICTED SIDE LOAD=	1.045					
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750
BOX DENSITY	5.063	5.063	5.063	5.063	5.063	5.063	5.063	5.063
STRUT DENSITY	6.671	6.671	6.671	6.671	6.671	6.671	6.671	6.671
MULL DENSITY	7.190	7.190	7.190	7.190	7.190	7.190	7.190	7.190
TOTAL DENSITY	5.899	5.899	5.899	5.899	5.899	5.899	5.899	5.899
BOX WEIGHT	708.504	708.504	708.504	708.504	708.504	708.504	708.504	708.504
STRUT WEIGHT	405.681	405.681	405.681	405.681	405.681	405.681	405.681	405.681
MULL WEIGHT	390.493	390.493	390.493	390.493	390.493	390.493	390.493	390.493
TOTAL WEIGHT	1504.758	1504.758	1504.758	1504.758	1504.758	1504.758	1504.758	1504.758

XL,DIALH,CP,TD,AG,ALUMS	471.000	21.700	.700	1.750	20.000	1.000		
XLS,XTNVS,CWP,STGAP	337.000	12.950	.750					
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	334.000	106.400	4.000	10.000	0.000	0.000		
BOX,STRUT,MULL,TOTAL VOLUME=	497526.	237464.	243870.	970060.				
DISP=	10012.	PREDICTED SIDE LOAD=	.945					
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750
BOX DENSITY	4.952	4.952	4.952	4.952	4.952	4.952	4.952	4.952
STRUT DENSITY	5.543	5.543	5.543	5.543	5.543	5.543	5.543	5.543
MULL DENSITY	6.773	6.773	6.773	6.773	6.773	6.773	6.773	6.773
TOTAL DENSITY	5.549	5.549	5.549	5.549	5.549	5.549	5.549	5.549
BOX WEIGHT	1099.927	1099.927	1099.927	1099.927	1099.927	1099.927	1099.927	1099.927
STRUT WEIGHT	587.606	587.606	587.606	587.606	587.606	587.606	587.606	587.606
MULL WEIGHT	737.418	737.418	737.418	737.418	737.418	737.418	737.418	737.418
TOTAL WEIGHT	2424.950	2424.950	2424.950	2424.950	2424.950	2424.950	2424.950	2424.950

XL,DIALH,CP,TD,AG,ALUMS	593.000	27.290	.700	1.750	20.000	1.000		
XLS,XTNVS,CWP,STGAP	426.000	16.300	.750					
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	420.000	134.100	4.000	10.000	0.000	0.000		
BOX,STRUT,MULL,TOTAL VOLUME=	700500.	421497.	405601.	1695606.				
DISP=	19965.	PREDICTED SIDE LOAD=	.935					
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750
BOX DENSITY	4.938	4.938	4.938	4.938	4.938	4.938	4.938	4.938
STRUT DENSITY	5.077	5.077	5.077	5.077	5.077	5.077	5.077	5.077
MULL DENSITY	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798
TOTAL DENSITY	5.505	5.505	5.505	5.505	5.505	5.505	5.505	5.505
BOX WEIGHT	1738.283	1738.283	1738.283	1738.283	1738.283	1738.283	1738.283	1738.283
STRUT WEIGHT	955.241	955.241	955.241	955.241	955.241	955.241	955.241	955.241
MULL WEIGHT	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799
TOTAL WEIGHT	4167.323	4167.323	4167.323	4167.323	4167.323	4167.323	4167.323	4167.323

XL,DIALH,CP,TD,AG,ALUMS	593.000	27.290	.700	1.750	20.000	1.000		
XLS,XTNVS,CWP,STGAP	426.000	16.300	.750					
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	420.000	134.100	4.000	10.000	0.000	0.000		
BOX,STRUT,MULL,TOTAL VOLUME=	1351728.	421497.	405601.	2250026.				
DISP=	19965.	PREDICTED SIDE LOAD=	.935					
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750
BOX DENSITY	3.952	3.952	3.952	3.952	3.952	3.952	3.952	3.952
STRUT DENSITY	5.077	5.077	5.077	5.077	5.077	5.077	5.077	5.077
MULL DENSITY	6.798	6.798	6.798	6.798	6.798	6.798	6.798	6.798
TOTAL DENSITY	4.774	4.774	4.774	4.774	4.774	4.774	4.774	4.774
BOX WEIGHT	2304.725	2304.725	2304.725	2304.725	2304.725	2304.725	2304.725	2304.725
STRUT WEIGHT	955.241	955.241	955.241	955.241	955.241	955.241	955.241	955.241
MULL WEIGHT	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799	1473.799
TOTAL WEIGHT	4733.765	4733.765	4733.765	4733.765	4733.765	4733.765	4733.765	4733.765

STRUCTURAL WEIGHT DATA  
THICK SINGLE STRUT

XL,DIALM,CP,TD,AG,ALUMS	273.000	13.170	.700	1.750	20.000	1.000			
XLS,XTNVS,CWP,STGAP	222.000	5.460	.750						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	100.000	67.700	4.000	10.000	0.000	0.000			
BOX,STRUT,MULL,TOTAL VOLUME=	170106.	54323.	52066.	204575.					
DISP=	2001. PREDICTED SIDE LOAD=	1.567							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.163	5.163	5.163	5.163	5.163	5.163	5.163	5.163	5.163
STRUT DENSITY	11.244	11.244	11.244	11.244	11.315	11.410	11.737	12.191	12.705
MULL DENSITY	7.927	7.927	7.927	7.927	7.927	7.927	7.927	7.927	7.927
TOTAL DENSITY	6.830	6.830	6.830	6.830	6.843	6.861	6.924	7.018	7.108
BOX WEIGHT	410.606	410.606	410.606	410.606	410.606	410.606	410.606	410.606	410.606
STRUT WEIGHT	272.609	272.609	272.609	272.609	274.390	276.696	284.640	295.642	308.105
MULL WEIGHT	184.261	184.261	184.261	184.261	184.261	184.261	184.261	184.261	184.261
TOTAL WEIGHT	867.636	867.636	867.636	867.636	869.344	871.643	879.506	890.509	903.851

XL,DIALM,CP,TD,AG,ALUMS	370.000	17.060	.700	1.750	20.000	1.000			
XLS,XTNVS,CWP,STGAP	302.000	7.400	.750						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	255.000	91.000	4.000	10.000	0.000	0.000			
BOX,STRUT,MULL,TOTAL VOLUME=	327726.	111947.	129772.	569445.					
DISP=	4991. PREDICTED SIDE LOAD=	1.470							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.989	4.989	4.989	4.989	4.989	5.250	5.566	5.877	6.490
STRUT DENSITY	8.653	8.653	8.653	8.731	9.077	9.648	10.299	10.997	11.723
MULL DENSITY	7.028	7.028	7.028	7.028	7.028	7.028	7.028	7.028	7.028
TOTAL DENSITY	6.174	6.174	6.174	6.189	6.257	6.520	6.830	7.146	7.641
BOX WEIGHT	729.934	729.934	729.934	729.934	729.934	768.048	814.309	859.809	949.468
STRUT WEIGHT	432.448	432.448	432.448	436.356	453.649	482.166	514.714	549.564	595.854
MULL WEIGHT	407.177	407.177	407.177	407.177	407.177	407.177	407.177	407.177	407.177
TOTAL WEIGHT	1569.559	1569.559	1569.559	1573.467	1590.759	1657.391	1736.280	1816.549	1942.498

XL,DIALM,CP,TD,AG,ALUMS	466.000	22.500	.700	1.750	20.000	1.000			
XLS,XTNVS,CWP,STGAP	380.000	9.330	.750						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	321.000	115.700	4.000	10.000	0.000	0.000			
BOX,STRUT,MULL,TOTAL VOLUME=	519956.	196105.	259399.	975460.					
DISP=	9975. PREDICTED SIDE LOAD=	1.387							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.992	4.992	4.992	5.329	5.802	7.141	8.686	10.231	11.775
STRUT DENSITY	7.127	7.127	7.139	7.564	8.274	9.074	9.919	10.790	11.677
MULL DENSITY	6.870	6.870	6.870	6.870	6.870	6.870	6.870	6.870	6.870
TOTAL DENSITY	5.921	5.921	5.923	6.188	6.625	7.457	8.451	9.449	10.451
BOX WEIGHT	1150.817	1150.817	1150.817	1236.000	1365.295	1657.497	2016.119	2374.741	2733.363
STRUT WEIGHT	623.948	623.948	625.032	662.190	724.381	794.430	868.406	944.628	1022.252
MULL WEIGHT	795.538	795.538	795.538	795.538	795.538	795.538	795.538	795.538	795.538
TOTAL WEIGHT	2570.295	2570.295	2579.387	2694.617	2885.215	3247.465	3680.063	4114.907	4551.153

XL,DIALM,CP,TD,AG,ALUMS	587.000	20.340	.700	1.750	20.000	1.000			
XLS,XTNVS,CWP,STGAP	479.000	11.750	.750						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	404.000	146.000	4.000	10.000	0.000	0.000			
BOX,STRUT,MULL,TOTAL VOLUME=	825776.	348290.	518300.	1692455.					
DISP=	19938. PREDICTED SIDE LOAD=	1.309							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.882	4.882	5.517	7.508	10.242	12.976	15.710	18.444	21.178
STRUT DENSITY	6.311	6.311	6.596	7.449	8.423	9.447	10.488	11.533	12.580
MULL DENSITY	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840
TOTAL DENSITY	5.776	5.776	6.144	7.291	8.825	10.370	11.910	13.467	15.017
BOX WEIGHT	1799.743	1799.743	2033.702	2767.645	3775.536	4783.426	5791.316	6799.206	7807.097
STRUT WEIGHT	981.284	981.284	1025.552	1150.157	1309.722	1468.872	1630.822	1793.262	1955.371
MULL WEIGHT	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937
TOTAL WEIGHT	4363.964	4363.964	4642.191	5500.740	6668.196	7835.235	9005.076	10175.486	11346.005

XL,DIALM,CP,TD,AG,ALUMS	587.000	20.340	.700	1.750	20.000	1.000			
XLS,XTNVS,CWP,STGAP	479.000	11.750	.750						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	404.000	146.000	4.000	10.000	0.000	0.000			
BOX,STRUT,MULL,TOTAL VOLUME=	1415616.	348290.	518300.	2282295.					
DISP=	19938. PREDICTED SIDE LOAD=	1.309							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	3.896	3.896	3.896	4.894	4.579	5.559	6.537	7.515	8.493
STRUT DENSITY	6.311	6.311	6.596	7.449	8.423	9.447	10.488	11.533	12.580
MULL DENSITY	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840	6.840
TOTAL DENSITY	4.933	4.933	4.976	5.230	5.679	6.443	7.209	7.975	8.741
BOX WEIGHT	2461.954	2461.954	2461.954	2987.429	2894.051	3513.136	4131.225	4749.314	5367.403
STRUT WEIGHT	981.284	981.284	1025.552	1150.157	1309.722	1468.872	1630.822	1793.262	1955.371
MULL WEIGHT	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937	1582.937
TOTAL WEIGHT	5026.176	5026.176	5070.443	5328.523	5786.711	6564.945	7344.984	8125.513	8906.311

STRUCTURAL WEIGHT DATA  
THIN SINGLE STRUT



XL,DIALH,CP,TD,AG,ALUMS	249.000	15.650	.600	1.620	20.000	1.000			
XLS,XTNVS,CMP,STGAP	76.000	4.840	.000						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	161.000	81.000	4.000	10.000	0.000	0.000			
BOX,STRUT,HULL,TOTAL VOLUME=	182574.	38459.	57478.	278511.					
DISP=	2001. PREDICTED SIDE LOAD=	.478							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	5.177	5.177	5.177	5.177	5.177	5.276	5.462	5.639	5.807
STRUT DENSITY	10.629	10.629	10.659	10.727	11.039	11.446	11.899	12.378	12.875
HULL DENSITY	8.084	8.084	8.084	8.084	8.084	8.084	8.084	8.084	8.084
TOTAL DENSITY	6.530	6.530	6.534	6.543	6.587	6.707	6.892	7.074	7.253
BOX WEIGHT	421.966	421.966	421.966	421.966	421.966	430.000	445.205	459.573	473.347
STRUT WEIGHT	182.497	182.497	183.000	184.183	189.535	196.514	204.294	212.530	221.052
HULL WEIGHT	207.437	207.437	207.437	207.437	207.437	207.437	207.437	207.437	207.437
TOTAL WEIGHT	811.899	811.899	812.403	813.586	818.937	833.951	856.935	879.548	901.836

XL,DIALH,CP,TD,AG,ALUMS	338.000	21.240	.600	1.620	20.000	1.000			
XLS,XTNVS,CMP,STGAP	103.000	6.570	.000						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	219.000	110.000	4.000	10.000	0.000	0.000			
BOX,STRUT,HULL,TOTAL VOLUME=	337260.	79009.	143713.	559982.					
DISP=	5002. PREDICTED SIDE LOAD=	.442							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.958	4.958	4.958	5.276	5.734	6.007	7.079	8.952	10.024
STRUT DENSITY	8.245	8.245	8.318	8.735	9.250	9.823	10.410	11.008	11.610
HULL DENSITY	7.343	7.343	7.343	7.343	7.343	7.343	7.343	7.343	7.343
TOTAL DENSITY	6.034	6.034	6.044	6.295	6.644	7.370	8.099	8.829	9.560
BOX WEIGHT	746.520	746.520	746.520	794.435	863.364	1024.842	1186.320	1347.798	1509.276
STRUT WEIGHT	290.823	290.823	293.405	308.098	326.540	346.481	367.173	388.283	409.511
HULL WEIGHT	471.085	471.085	471.085	471.085	471.085	471.085	471.085	471.085	471.085
TOTAL WEIGHT	1508.428	1508.428	1511.011	1573.610	1660.989	1842.408	2024.578	2207.166	2389.871

XL,DIALH,CP,TD,AG,ALUMS	426.000	26.750	.600	1.620	20.000	1.000			
XLS,XTNVS,CMP,STGAP	130.000	8.270	.000						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	275.000	138.000	4.000	10.000	0.000	0.000			
BOX,STRUT,HULL,TOTAL VOLUME=	531300.	138451.	287295.	957045.					
DISP=	10002. PREDICTED SIDE LOAD=	.416							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.933	4.933	5.453	7.090	8.970	10.866	12.755	14.643	16.531
STRUT DENSITY	6.748	6.748	7.085	7.681	8.335	9.006	9.679	10.354	11.030
HULL DENSITY	7.399	7.399	7.399	7.399	7.399	7.399	7.399	7.399	7.399
TOTAL DENSITY	5.936	5.936	6.273	7.268	8.411	9.556	10.702	11.848	12.994
BOX WEIGHT	1170.144	1170.144	1293.423	1681.649	2129.511	2577.373	3025.235	3473.097	3920.959
STRUT WEIGHT	417.111	417.111	437.909	474.773	515.145	556.636	598.273	639.976	681.717
HULL WEIGHT	948.976	948.976	948.976	948.976	948.976	948.976	948.976	948.976	948.976
TOTAL WEIGHT	2536.231	2536.231	2680.308	3105.398	3593.632	4082.985	4572.483	5062.049	5551.652

XL,DIALH,CP,TD,AG,ALUMS	536.000	33.700	.600	1.620	20.000	1.000			
XLS,XTNVS,CMP,STGAP	164.000	10.420	.000						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	347.000	174.000	4.000	10.000	0.000	0.000			
BOX,STRUT,HULL,TOTAL VOLUME=	845292.	245988.	573714.	1664994.					
DISP=	19983. PREDICTED SIDE LOAD=	.390							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	4.869	5.253	8.070	11.421	14.771	18.121	21.472	24.822	28.172
STRUT DENSITY	6.033	6.075	6.710	7.459	8.220	8.983	9.747	10.511	11.275
HULL DENSITY	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726
TOTAL DENSITY	6.035	6.227	7.751	9.562	11.375	13.189	15.003	16.817	18.631
BOX WEIGHT	1844.921	1982.468	3045.394	4389.684	5573.974	6838.264	8102.554	9366.844	10631.134
STRUT WEIGHT	662.526	667.895	736.911	819.133	902.686	986.468	1070.328	1154.246	1238.193
HULL WEIGHT	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742
TOTAL WEIGHT	4486.189	4629.105	5761.048	7187.559	8455.403	9803.466	11151.625	12499.833	13848.070

XL,DIALH,CP,TD,AG,ALUMS	536.000	33.700	.600	1.620	20.000	1.000			
XLS,XTNVS,CMP,STGAP	164.000	10.420	.000						
XLENG,WIDTH,MINNR,DECK(1),DECK(2),DECK(3)	347.000	174.000	4.000	10.000	0.000	0.000			
BOX,STRUT,HULL,TOTAL VOLUME=	1449072.	245988.	573714.	2268774.					
DISP=	19983. PREDICTED SIDE LOAD=	.390							
SIDE LOAD	0.000	.250	.500	.750	1.000	1.250	1.500	1.750	2.000
BOX DENSITY	3.903	3.903	4.217	5.448	6.642	7.836	9.030	10.224	11.418
STRUT DENSITY	6.033	6.075	6.710	7.459	8.220	8.983	9.747	10.511	11.275
HULL DENSITY	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726	7.726
TOTAL DENSITY	5.100	5.105	5.375	6.242	7.087	7.932	8.778	9.623	10.469
BOX WEIGHT	2524.672	2524.672	2727.905	3524.354	4296.738	5069.106	5841.482	6613.857	7386.233
STRUT WEIGHT	662.526	667.895	736.911	819.133	902.686	986.468	1070.328	1154.246	1238.193
HULL WEIGHT	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742	1978.742
TOTAL WEIGHT	5165.940	5170.589	5443.559	6322.229	7176.158	8034.308	8898.552	9766.846	10603.169

STRUCTURAL WEIGHT DATA  
MULTI STRUT

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